Electronic Version
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Claims

[c1] WHAT IS CLAIMED IS:

1. A switching DC-to-DC converter, comprising:

a first power supply channel coupled between a DC voltage source and ground, for converting the DC voltage source to a first DC output voltage;

a second power supply channel coupled between the DC voltage source and ground, for converting the DC voltage source to a second DC output voltage which is separate from the first DC output voltage; and

an oscillator for outputting a first oscillating signal having a first period to the first power supply channel and for outputting a second oscillating signal having a second period to the second power supply channel,

wherein:

during each period of the first period, the first oscillating signal presents a peak, a valley, a rising portion gradually increasing from the valley toward the peak, and a falling portion gradually decreasing from the peak toward the valley, such that at least one switching transition of the first power supply channel occurs during one selected from a group consisting of the rising portion and the falling portion; and

during each period of the second period, the second oscillating signal presents an instantly transiting edge which simultaneously occurs with one selected from a group consisting of the peak and the valley, such that at least one switching transition of the second power supply channel simultaneously occurs with the instantly transiting edge.

[c2] 2. The converter according to claim 1, wherein the first oscillating signal is a triangular wave signal.

[c3] 3.The converter according to claim 1, wherein:
the second oscillating signal is a pulse wave signal which presents a rising edge, a pulse width, and a falling edge during each period of the second period, and
the instantly transiting edge of the second oscillating signal refers to the rising edge thereof.

[c4] 4.The converter according to claim 1, wherein:
the oscillator includes:
a valley comparator for comparing the first oscillating signal with a valley setting voltage, and
an inverter having an input terminal coupled to an output terminal of the valley comparator, for generating the second oscillating signal.

[c5] 5.The converter according to claim 1, wherein:

the oscillator includes:

a peak comparator for comparing the first oscillating signal with a peak setting voltage;

a valley comparator for comparing the first oscillating signal with a valley setting voltage;

a latch having a setting input and a resetting input for outputting a normal output, the setting input being coupled to an output terminal of the peak comparator and the resetting input being coupled to an output terminal of the valley comparator; and

a rising edge one shot generator for generating the second oscillating signal in response to the normal output.

[c6] 6.The converter according to claim 1, wherein the oscillator further outputs a first auxiliary signal to the second power supply channel, in which the first auxiliary signal is a ramp wave signal presenting a rising portion and a falling edge such that the falling edge thereof simultaneously occurs with the instantly transiting edge of the second oscillating signal.

[c7] 7.The converter according to claim 6, wherein the second power supply channel performs slop compensation of current mode feedback control by using the first auxiliary signal.

[c8] 8.The converter according to claim 6, wherein:

the oscillator includes:

a peak comparator for comparing the first oscillating signal with a peak setting voltage;

a valley comparator for comparing the first oscillating signal with a valley setting voltage;

a first inverter having an input terminal coupled to an output terminal of the valley comparator, for generating the second oscillating signal;

a second inverter having an input terminal coupled to an output terminal of the peak comparator;

an auxiliary output node for outputting the first auxiliary signal;

a sample-and-hold amplifier, controlled by the second inverter, for comparing the first auxiliary signal with a reference voltage;

a sample-and-hold capacitor coupled between an output terminal of the sample-and-hold amplifier and the ground;

a voltage-to-current converter having a voltage input terminal and a current output terminal, the voltage input terminal being coupled to the output terminal of the sample-and-hold amplifier and the current output terminal being coupled to the auxiliary output node;

an output capacitor coupled between the auxiliary output node and ground; and

a switching means controlled by the first inverter and

coupled between the auxiliary output node and ground.

[c9] 9.The converter according to claim 8, wherein the reference voltage is a half of an amplitude maximum of the first auxiliary signal.

[c10] 10.The converter according to claim 6, wherein:
the oscillator includes:
a peak comparator for comparing the first oscillating signal with a peak setting voltage;
a valley comparator for comparing the first oscillating signal with a valley setting voltage;
a latch having a setting input and a resetting input for outputting a normal output, the setting input being coupled to an output terminal of the peak comparator and the resetting input being coupled to an output terminal of the valley comparator;
a rising edge one shot generator for generating the second oscillating signal in response to the normal output;
a falling edge one shot generator for receiving the normal output;
an auxiliary output node for outputting the first auxiliary signal;
a sample-and-hold amplifier, controlled by the falling edge one shot generator, for comparing the first auxiliary signal with a reference voltage;
a sample-and-hold capacitor coupled between an output

terminal of the sample-and-hold amplifier and the ground;

a voltage-to-current converter having a voltage input terminal and a current output terminal, the voltage input terminal being coupled to the output terminal of the sample-and-hold amplifier and the current output terminal being coupled to the auxiliary output node;

an output capacitor coupled between the auxiliary output node and ground; and

a switching means controlled by the rising edge one shot generator and coupled between the auxiliary output node and ground.

[c11] 11.The converter according to claim 1, further comprising:

a third power supply channel coupled between the DC voltage source and ground, for converting the DC voltage source to a third DC output voltage which is separate from the first and second DC output voltages, wherein:

the oscillator further outputs a third oscillating signal having a third period to the third power supply channel;

during each period of the third period, the third oscillating signal presents a peak, a valley, a rising portion gradually increasing from the valley toward the peak, and a falling portion gradually decreasing from the peak

toward the valley, such that the peak of the third oscillating signal simultaneously occurs with the valley of the first oscillating signal while the valley of the third oscillating signal simultaneously occurs with the peak of the first oscillating signal; and

at least one switching transition of the third power supply channel occurs during one selected from a group consisting of the rising portion and the falling portion of the third oscillating signal.

[c12] 12.Theconverter according to claim 11, wherein the thirdoscillating signal is a signal inverted from the first oscillating signal.

[c13] 13.The converter according to claim 1, further comprising:

a fourth power supply channel coupled between the DC voltage source and ground, for converting the DC voltage source to a fourth DC output voltage which is separate from the first and second DC output voltages, wherein:

the oscillator further outputs a fourth oscillating signal having a fourth period to the fourth power supply channel;

during each period of the fourth period, the fourth oscillating signal presents an instantly transiting edge which simultaneously occurs with one selected from a group

consisting of the peak and the valley of the first oscillating signal;
the instantly transiting edge of the fourth oscillating signal occurs after a predetermined delay with respect to the instantly transiting edge of the second oscillating signal; and
at least one switching transition of the fourth power supply channel simultaneously occurs with the instantly transiting edge of the fourth oscillating signal.

[c14] 14.The converter according to claim 13, wherein the predetermined delay is a half of the second period.

[c15] 15.The converter according to claim 13, wherein:
the fourth oscillating signal is a pulse wave signal which presents a rising edge, a pulse width, and a falling edge during each period of the fourth period, and
the instantly transiting edge of the fourth oscillating signal refers to the rising edge thereof.

[c16] 16.The converter according to claim 13, wherein the oscillator further outputs a second auxiliary signal to the fourth power supply channel, in which the second auxiliary signal is a ramp wave signal presenting a rising portion and a falling edge such that the falling edge thereof simultaneously occurs with the instantly transiting edge of the fourth oscillating signal.

[c17] 17.The converter according to claim 16, wherein the fourth power supply channel performs slop compensation of current mode feedback control by using the second auxiliary signal.

[c18] 18.The converter according to claim 16, wherein the outputting of the second auxiliary signal from the oscillator is implemented by using the second and fourth oscillating signals.

[c19] 19.The converter according to claim 16, wherein:
the oscillator includes:
an auxiliary output node for outputting the second auxiliary signal;
a sample-and-hold amplifier, controlled by the second oscillating signal, for comparing the second auxiliary signal with a reference voltage;
a sample-and-hold capacitor coupled between an output terminal of the sample-and-hold amplifier and the ground;
a voltage-to-current converter having a voltage input terminal and a current output terminal, the voltage input terminal being coupled to the output terminal of the sample-and-hold amplifier and the current output terminal being coupled to the auxiliary output node;
an output capacitor coupled between the auxiliary output

node and ground; and

a switching means controlled by the fourth oscillating signal and coupled between the auxiliary output node and ground.

[c20] 20.A switching DC-to-DC converter, comprising:

a plurality of power supply channels connected in parallel between a DC voltage source and ground;

an oscillating signal generator, including:

an oscillating output node coupled to a first power supply channel of the plurality of power supply channels;

a peak comparator having a non-inverting terminal and an inverting terminal, the non-inverting terminal being coupled to a peak setting voltage and the inverting terminal being coupled to the oscillating output node;

a valley comparator having an inverting terminal and a non-inverting terminal, the inverting terminal being coupled to a valley setting voltage and the non-inverting terminal being coupled to the oscillating output node;

a latch having a setting input and a resetting input, the setting input being coupled to an output terminal of the peak comparator and the resetting input being coupled to an output terminal of the valley comparator;

a first inverter having an input terminal coupled to a normal output of the latch;

a first switching means controlled by the first inverter;

a first current source for supplying a first current from the DC voltage source to the oscillating output node;
a second current source, controlled by the first switching means, for flowing a second current from the oscillating output node to the ground; and
a first output capacitor coupled between the oscillating output node and ground; and
an auxiliary signal generator, including:
an auxiliary output node coupled to a second power supply channel of the plurality of power supply channels;
a sample-and-hold amplifier, controlled by the oscillating signal generator, having a non-inverting terminal and an inverting terminal, the non-inverting terminal being coupled to a reference voltage and the inverting terminal being coupled to the auxiliary output node;
a sample-and-hold capacitor coupled between an output terminal of the sample-and-hold amplifier and ground;
a voltage-to-current converter having a voltage input terminal and a current output terminal, the voltage input terminal being coupled to the output terminal of the sample-and-hold amplifier and the current output terminal being coupled to the auxiliary output node;
a second output capacitor coupled between the auxiliary output node and ground; and
a second switching means controlled by the oscillating signal generator and coupled between the auxiliary out-

put node and ground.

[c21] 21.The converter according to claim 20, further comprising:
a rising edge one shot generator having an input terminal coupled to the normal output of the latch, and
a falling edge one shot generator having an input terminal coupled to the normal output of the latch, wherein:
the sample-and-hold amplifier is controlled by one of the rising edge and the falling edge one shot generators while the second switching means is controlled by another of the rising edge and the falling edge one shot generators.

[c22] 22.The converter according to claim 20, further comprising:
a second inverter having an input terminal coupled to the resetting input of the latch, and
a third inverter having an input terminal coupled to the setting input of the latch, wherein:
the sample-and-hold amplifier is controlled by one of the second and the third inverters while the second switching means is controlled by another of the second and the third inverters.

[c23] 23.The converter according to claim 20, further comprising:

an inverting means having an input terminal and an output terminal, the input terminal being coupled to the oscillating output node and the output terminal being coupled to a third power supply channel of the plurality of power supply channels.

[c24] 24.An oscillator,comprising:
means for outputting a first oscillating signal having a first period, and
means for outputting a second oscillating signal having a second period, wherein:
during each period of the first period, the first oscillating signal presents a peak, a valley, a rising portion gradually increasing from the valley toward the peak, and a falling portion gradually decreasing from the peak toward the valley, and
during each period of the second period, the second oscillating signal presents an instantly transiting edge which simultaneously occurs with one selected from a group consisting of the peak and the valley.

[c25] 25.The oscillator according to claim 24, wherein the first oscillating signal is a triangular wave signal.

[c26] 26.The oscillator according to claim 24,wherein:
the second oscillating signal is a pulse wave signal which presents a rising edge, a pulse width, and a falling edge

during each period of the second period, and
the instantly transiting edge of the second oscillating signal refers to the rising edge thereof.

[c27] 27.The oscillator according to claim 24, further comprising:
means for outputting a first auxiliary signal, which is a ramp wave signal presenting a rising portion and a falling edge such that the falling edge thereof simultaneously occurs with the instantly transiting edge of the second oscillating signal.

[c28] 28.The oscillator according to claim 24,further comprising:
means for outputting a third oscillating signal having a third period, wherein:
during each period of the third period, the third oscillating signal presents a peak, a valley, a rising portion gradually increasing from the valley toward the peak, and a falling portion gradually decreasing from the peak toward the valley, such that the peak of the third oscillating signal simultaneously occurs with the valley of the first oscillating signal while the valley of the third oscillating signal simultaneously occurs with the peak of the first oscillating signal.

[c29] 29.The oscillator according to claim 28,wherein the third

oscillating signal is an inverted signal of the first oscillating signal.

[c30] 30.The oscillator according to claim 24,further comprising:
means for outputting a fourth oscillating signal having a fourth period, wherein:
during each period of the fourth period, the fourth oscillating signal presents an instantly transiting edge which simultaneously occurs with one selected from a group consisting of the peak and the valley of the first oscillating signal, and
the instantly transiting edge of the fourth oscillating signal occurs after a predetermined delay with respect to the instantly transiting edge of the second oscillating signal.

[c31] 31.The oscillator according to claim 30,wherein:
the fourth oscillating signal is a pulse wave signal which presents a rising edge, a pulse width, and a falling edge during each period of the fourth period, and
the instantly transiting edge of the fourth oscillating signal refers to the rising edge thereof.

[c32] 32.The oscillator according to claim 30,further comprising:
means for outputting a second auxiliary signal, which is

a ramp wave signal presenting a rising portion and a falling edge such that the falling edge thereof simultaneously occurs with the instantly transiting edge of the fourth oscillating signal.